

PATENT COOPERATION TREATY

PCT

INTERNATIONAL PRELIMINARY REPORT ON PATENTABILITY



(Chapter II of the Patent Cooperation Treaty)

(PCT Article 36 and Rule 70)

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Applicant's or agent's file reference 32613-WO-U	FOR FURTHER ACTION		See Form PCT/IPEA/416
International application No. PCT/BE2005/000023	International filing date (day/month/year) 17.02.2005	Priority date (day/month/year) 23.02.2004	
International Patent Classification (IPC) or national classification and IPC F16C37/00, F16C33/66, H02K9/19, H02K5/173			
Applicant ATLAS COPCO AIRPOWER, NAAMLOZE VENNOOTSCHAP et al.			
<p>1. This report is the international preliminary examination report, established by this International Preliminary Examining Authority under Article 35 and transmitted to the applicant according to Article 36.</p> <p>2. This REPORT consists of a total of 6 sheets, including this cover sheet.</p> <p>3. This report is also accompanied by ANNEXES, comprising:</p> <p>a. <input checked="" type="checkbox"/> sent to the applicant and to the International Bureau) a total of 15 sheets, as follows:</p> <p><input checked="" type="checkbox"/> sheets of the description, claims and/or drawings which have been amended and are the basis of this report and/or sheets containing rectifications authorized by this Authority (see Rule 70.16 and Section 607 of the Administrative Instructions).</p> <p><input type="checkbox"/> sheets which supersede earlier sheets, but which this Authority considers contain an amendment that goes beyond the disclosure in the international application as filed, as indicated in item 4 of Box No. I and the Supplemental Box.</p> <p>b. <input type="checkbox"/> (sent to the International Bureau only) a total of (indicate type and number of electronic carrier(s)) , containing a sequence listing and/or tables related thereto, in computer readable form only, as indicated in the Supplemental Box Relating to Sequence Listing (see Section 802 of the Administrative Instructions).</p>			
<p>4. This report contains indications relating to the following items:</p> <p><input checked="" type="checkbox"/> Box No. I Basis of the opinion</p> <p><input type="checkbox"/> Box No. II Priority</p> <p><input type="checkbox"/> Box No. III Non-establishment of opinion with regard to novelty, inventive step and industrial applicability</p> <p><input type="checkbox"/> Box No. IV Lack of unity of invention</p> <p><input checked="" type="checkbox"/> Box No. V Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement</p> <p><input type="checkbox"/> Box No. VI Certain documents cited</p> <p><input type="checkbox"/> Box No. VII Certain defects in the international application</p> <p><input checked="" type="checkbox"/> Box No. VIII Certain observations on the international application</p>			
Date of submission of the demand 15.07.2005		Date of completion of this report 10.02.2006	
Name and mailing address of the international preliminary examining authority:  European Patent Office - P.B. 5818 Patentlaan 2 NL-2280 HV Rijswijk - Pays Bas Tel. +31 70 340 - 2040 Tx: 31 651 epo nl Fax: +31 70 340 - 3016		Authorized Officer Béguin-Adriaenssens, Telephone No. +31 70 340-3056 	

**INTERNATIONAL PRELIMINARY REPORT
ON PATENTABILITY**

International application No.
PCT/BE2005/000023

Box No. I Basis of the report

1. With regard to the **language**, this report is based on the international application in the language in which it was filed, unless otherwise indicated under this item.
- ☒ This report is based on translations from the original language into the following language english, which is the language of a translation furnished for the purposes of:
- ☐ international search (under Rules 12.3 and 23.1(b))
 - ☐ publication of the international application (under Rule 12.4)
 - ☒ international preliminary examination (under Rules 55.2 and/or 55.3)
2. With regard to the **elements*** of the international application, this report is based on *(replacement sheets which have been furnished to the receiving Office in response to an invitation under Article 14 are referred to in this report as "originally filed" and are not annexed to this report)*:

Description, Pages

1, 2, 7, 11-14	as originally filed
3, 3a, 3b, 4, 5, 5a, 5b, 6, 8-10	received on 15.07.2005 with letter of 12.07.2005

Claims, Numbers

1-14	received on 15.07.2005 with letter of 12.07.2005
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Drawings, Sheets

1/5-5/5	as originally filed
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- ☐ a sequence listing and/or any related table(s) - see Supplemental Box Relating to Sequence Listing

3. ☐ The amendments have resulted in the cancellation of:
- ☐ the description, pages
 - ☐ the claims, Nos.
 - ☐ the drawings, sheets/figs
 - ☐ the sequence listing (*specify*):
 - ☐ any table(s) related to sequence listing (*specify*):
4. ☐ This report has been established as if (some of) the amendments annexed to this report and listed below had not been made, since they have been considered to go beyond the disclosure as filed, as indicated in the Supplemental Box (Rule 70.2(c)).
- ☐ the description, pages
 - ☐ the claims, Nos.
 - ☐ the drawings, sheets/figs
 - ☐ the sequence listing (*specify*):
 - ☐ any table(s) related to sequence listing (*specify*):

* If item 4 applies, some or all of these sheets may be marked "superseded."

**INTERNATIONAL PRELIMINARY REPORT
ON PATENTABILITY**

International application No.
PCT/BE2005/000023

Box No. V Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1. Statement

Novelty (N)	Yes: Claims	1-14
	No: Claims	
Inventive step (IS)	Yes: Claims	1-14
	No: Claims	
Industrial applicability (IA)	Yes: Claims	1-14
	No: Claims	

2. Citations and explanations (Rule 70.7):

see separate sheet

Box No. VIII Certain observations on the international application

The following observations on the clarity of the claims, description, and drawings or on the question whether the claims are fully supported by the description, are made:

see separate sheet

Re Item V

Reasoned Statement with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such Statement.

1 Reference is made to the following documents

- D1: GB 595 346 A (FRANCIS EDGAR BAUMANN; VICKERS ELECTRICAL CO LTD; HAYNE CONSTANT; DAVI) 3 December 1947 (1947-12-03)
- D2: PATENT ABSTRACTS OF JAPAN vol. 2000, no. 13, 5 February 2001 (2001-02-05) & JP 2000 291674 A (ISUZU MOTORS LTD), 20 October 2000 (2000-10-20)
- D3: FR-A-2 168 145 (ALSTHOM CGEE) 31 August 1973 (1973-08-31)
- D4: PATENT ABSTRACTS OF JAPAN vol. 009, no. 014 (M-352), 22 January 1985 (1985-01-22) & JP 59 161201 A (OKUMA TEKKOSHO KK), 12 September 1984 (1984-09-12)
- D5: EP-A-0 289 610 (FANUC LTD) 9 November 1988 (1988-11-09)
- D6: DE 87 05 477 U (SIEMENS) 11 August 1988 (1988-08-11)
- D7: US-A-2 770 891 (WENDEL LORENZ A) 20 November 1956 (1956-11-20)
- D8: US-B2-6 579 078 (HILL RAYMOND M ET AL) 17 June 2003 (2003-06-17)

2 NOVELTY OF INDEPENDENT CLAIM 1.

- 2.1 The document D1 is regarded as being the closest prior art to the subject-matter of claim 1, and shows (the references in parentheses applying to this document):

Machine with an improved bearing lubrication, which machine mainly consists of a housing (5) and a rotor (1) which is provided on a shaft (9), provided in a rotatable manner in the above-mentioned housing (5) by means of oil-lubricated bearings (10,11), whereby, inside the housing (5), lubrication ducts (29,32) are provided to supply and discharge oil to and from the bearings (10,11), the machine being provided with cooling channels (38,40) to supply and discharge a cooling agent, which cooling channels (38,40) open opposite to the

shaft (9), in a place between the rotor (1) and an above-mentioned bearing.

- 2.2 The subject-matter of claim 1 of the application differs from this known support bearing in that (references applying to the application document) :

The cooling channels (21,15) are connected to the lubrication ducts (14).

As no document from the cited prior art discloses such a support bearing, the subject-matter of claim 1 is therefore new (Article 33(2) PCT).

3. INVENTIVE STEP OF INDEPENDENT CLAIM 1

- 3.1 The problem to be solved by the present invention may be regarded as: the manufacture of the bearing lubrication system is made simpler and more effective.
- 3.2 The solution to this problem proposed in claim 1 is: the cooling agent for the shaft comes from the same oil conduct as the oil which is used for lubricating the bearing, no separate circuits required.
- 3.3 These features result from a step being non-obvious in view of the cited prior art. From document D1, the cooling and lubricating circuits are separated as the media employed are from different natures: oil, air and water. This do not give any suggestion to the skilled person to modify a machine with bearing lubrication as described in document D1 to the manner specified in claim 1. i.e. by using one and onely circuit for cooling and lubricating.

The present application is considered as involving an inventive step (Article 33(3) PCT).

4. DEPENDENT CLAIMS

Claims 2-14 are dependent on claim 1 and as such also meet the requirements of the PCT with respect to novelty and inventive step.

5. INDUSTRIAL APPLICABILITY

The subject matter of claims 1-14 can be manufactured in industry, thus looked upon as being industrially applicable.

Re Item VIII

Certain observations on the international application

The present figure 1, and the related written part of the description (page 7), do not fall within the scope of the present claim 1 (Article 6 PCT).

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apparent at high rotational speeds, ⁽⁵⁴⁾ leading to a lower efficiency of the bearing as such, and consequently of the machine as a whole.

Especially in the case of high-speed motors, which are very compact, said phenomenon occurs, as the heat resulting from the mechanical and electric losses in the motor shaft can only be dissipated via a limited surface.

Another disadvantage of the bearings being warmed up, is that the bearing cage must usually be made of a special material which resists high temperatures, which is expensive.

When ball bearings with an angular contact are used, the problem of the bearing losses is further increased as a result of the pumping operation of this type of bearing.

From US 6,579,078 is known a centrifugal compressor which is driven by a high-speed motor and which is bearing-mounted in a housing, whereby the lubricating oil of the slide bearings also serves to cool the bearings. → 3A

The basic idea of US 6,579,078 is to direct cooled oil through the slide bearings in order to cool and lubricate the bearings and to moreover use the excessive oil going through the bearing to flow onto the shaft and to thus cool the latter.

The excessive lubrication of the bearings leads to additional stilling losses, and the cooling oil is moreover heated in this bearing, as a result of which the

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-3A-

GB 595.346 describes a machine in the form of a turbine or a compressor, which is provided with a bearing which is lubricated by means of an oil mist. Further said GB 595.346 describes the presence of a separate cooling circuit which
5 uses air or gas to cool the shaft of the machine.

A disadvantage of such known machines is that they are complex and require completely separate circuits for cooling the shaft and lubricating the bearing. Also, the
10 air or gas cooling will be insufficient for cooling the shaft and for realizing a proper functioning and a long life of the machine.

→ 3B

- 3 B -

~~apparent at high rotational speeds, leading to a~~
lower efficiency of the bearing as such, and
consequently of the machine as a whole.

Especially in the case of high-speed motors, which are
5 very compact, said phenomenon occurs, as the heat
resulting from the mechanical and electric losses in the
motor shaft can only be dissipated via a limited surface.

Another disadvantage of the bearings being warmed up, is
that the bearing cage must usually be made of a special
10 material which resists high temperatures, which is
expensive.

When ball bearings with an angular contact are used,
the problem of the bearing losses is further increased as
~~a result of the pumping operation of this type of bearing~~

15 From US 6,579,078 is known a centrifugal compressor which
is driven by a high-speed motor and which is bearing-
mounted in a housing, whereby the lubricating oil of
the slide bearings also serves to cool the bearings.

The basic idea of US 6,579,078 is to direct cooled oil
20 through the slide bearings in order to cool and lubricate
the bearings and to moreover use the excessive oil going
through the bearing to flow onto the shaft and to thus
cool the latter.

The excessive lubrication of the bearings leads to
25 additional stilling losses, and the cooling oil is
moreover heated in this bearing, as a result of which the

→ 4

shaft, which is irrigated by said oil, will be cooled less efficiently.

However, these additional cooling methods are not efficient and require additional measures, in this case
5 in the form of compressed air injection, in order to avoid that oil ends up in the space between the rotor and the stator. The present invention aims to remedy one or several of the above-mentioned and other disadvantages:

10 To this end, the invention concerns a machine with an improved bearing lubrication, which machine mainly consists of a housing and of a rotor provided on a shaft which is provided in the above-mentioned housing in a rotatable manner by means of oil-lubricated bearings,
15 whereby lubrication ducts are provided in the housing to supply and discharge oil to and from the bearings, and whereby it is provided with cooling channels to supply and discharge a cooling agent, which cooling channels open opposite to the shaft, in a place between the rotor
20 and the above-mentioned bearing *and whereby the above-mentioned cooling channels are connected to the above-mentioned lubrication ducts.*

An advantage of the invention is that no excessive amount of oil must be sent to the bearings in order to cool the bearings, as a result of which this amount of oil can be optimized for sufficient lubricating film to be built
25 up, such that the bearing losses are strongly reduced.

Another advantage is that, thanks to the direct injection of a cooling agent on the shaft, the heat flow of the rotor to the bearing is interrupted, as a result of

which a reduced heat flow flows to the bearing and as a result of which also the life of the bearing is extended, since the viscosity of the oil is not affected by the temperature of the bearing.

- 5 An additional advantage of the lower temperature of the bearing is that a standard bearing cage can be used for the bearings, as a result of which the cost price of the bearings can be lowered.

→ 5A

- 10 ~~According to a preferred characteristic of the invention~~
the rotor shaft is provided, opposite to the cooling channels, with one or several grooves.

- 15 This offers the major advantage that the contact surface between the cooling agent and the shaft increases, which considerably improves the cooling of the shaft.

- 20 In a preferred embodiment, the above-mentioned cooling channels extend through a gasket, which is provided with sealing lips directed towards the shaft on both sides of the above-mentioned grooves.

An advantage thereof is that no additional measures must be taken to prevent oil from entering between the rotor and the stator.

- 25 In a practical embodiment of a machine with an improved bearing lubrication according to the invention, the above-mentioned cooling channels are connected to the above-mentioned lubrication ducts, such that the lubricating oil also serves as a cooling agent for the shaft.

- 5A -

Still another advantage of such a machine according to the invention is that the lubricating oil also serves as a cooling agent for the shaft, which allows to make the construction of the machine compact, relatively cheap and
5 simple as it does not require the presence of separate circuits.

—→ 5B

- 5 6 -

~~which a reduced heat flow flows to the bearing and as a~~
result of which also the life of the bearing is extended,
since the viscosity of the oil is not affected by the
temperature of the bearing.

- 5 An additional advantage of the lower temperature of the
bearing is that a standard bearing cage can be used for
the bearings, as a result of which the cost price of the
~~bearings can be lowered.~~

10 According to a preferred characteristic of the invention,
the rotor shaft is provided, opposite to the cooling
channels, with one or several grooves.

15 This offers the major advantage that the contact surface
between the cooling agent and the shaft increases, which
considerably improves the cooling of the shaft.

20 In a preferred embodiment, the above-mentioned cooling
channels extend through a gasket, which is provided with
sealing lips directed towards the shaft on both sides of
the above-mentioned grooves.

An advantage thereof is that no additional measures must
be taken to prevent oil from entering between the rotor
and the stator.

25 ~~In a practical embodiment of a machine with an improved~~
bearing lubrication according to the invention, the above-
mentioned cooling channels are connected to the above-
mentioned lubrication ducts, such that the lubricating
~~oil also serves as a cooling agent for the shaft.~~

→ 6

~~This offers the advantage that only one external hydraulic circuit must be provided, which makes the construction as a whole compact, relatively cheap and simple.~~

5 In the most preferred embodiment, a thermal barrier is also provided between the place where the cooling liquid is injected on the above-mentioned shaft and the bearing, whereby this thermal barrier consists of a material layer which is a bad heat conductor.

10 In this manner, the heat flow from the shaft to the bearings is minimized, and the life of the bearings is extended.

15 If the machine with improved bearing lubrication is an electric motor or generator, the cooling channels extend in the bearing cap which seals the housing, and the winding heads of the electric coils are cased in a heat-conducting material, for example a heat-conducting paste or epoxy or silicone, sprayed around the heads and which makes contact with the above-mentioned bearing cap.

20 By providing the bearing plate with a cooling, it is also possible to dissipate heat from the winding heads in the axial direction, which is essential for example in case of enclosed permanent magnetic motors.

25 In order to better explain the characteristics of the present invention, the following preferred embodiments of a machine with an improved bearing

In the bearing cap 4 are also provided lubrication ducts 14 and separate cooling channels 15, whereby each of the above-mentioned lubrication ducts 14 open via an opening 16 in the above-mentioned outer ring 13 of the spacer sleeve 11 and, opposite to the inner ring 12, in a space 17, which extends axially between the above-mentioned bearings 7 and which extends radially between the above-mentioned concentric rings 12 and 13 of the spacer sleeve 11.

10 Around the shaft 6 is provided a gasket 18, which is provided with a standing side wall 19 against the above-mentioned bearing cap 4 and which is provided with two sealing lips 20 directed towards the shaft 6, which are connected to the shaft 6 with a very small clearance and which are situated at a distance from each other.

In the above-mentioned gasket 18 are also provided channels 21, which open opposite to the shaft 6, between the above-mentioned sealing lips 20, and in a place between the rotor 5 and the above-mentioned bearings 7.

20 The above-mentioned cooling channels 15 in the bearing cap 4 are connected onto the channels 21 of the gasket 18 and thus form a single continuous cooling channel 15, 21.

Between the above-mentioned sealing lips 20 are provided 25 grooves 22 in the shaft 6, opposite to the channels 21 of the gasket 18.

The above-mentioned cooling channels 21 are preferably directed tangentially onto the shaft 6, at their outlet at the shaft 6, according to the rotational direction of the shaft 6.

5 The above-mentioned lubrication ducts 14 are part of a conventional lubrication circuit 23, which is represented by means of a dashed line in the figure and which is provided with a reservoir 24 with lubricating oil and a hydraulic pump 25.

10 The above-mentioned cooling channels 15, 21 are in this case part of a cooling circuit 26 which also comprises, apart from a hydraulic pump 25 and a reservoir 24, a cooling device 27.

15 In the bearing cap 4 is provided a channel 28 at the bottom, which is connected to the inner space of the housing 2.

The working of such a motor 1 with an improved bearing lubrication is very simple and as follows.

20 When the motor 1 is excited, the rotor 5 is being driven and the bearings 7 of the rotor shaft 6 are lubricated by means of the lubrication circuit 23, whereby the pump 25 draws in lubricating oil from the reservoir 24 and directs this via the lubrication ducts 14 and the space 17 between the bearings 7, towards the
25 bearings 7.

The lubricating oil delivery can hereby be adjusted with

great precision, such that a lubricating film is built up to a desired degree.

When the pump 25 in the cooling circuit 26 is switched on, cooling oil is in this case drawn in from a reservoir 24 and injected via a cooling device 27 and the first cooling channel 15, 21 onto the shaft 6, between the sealing lips 20.

The cooling oil is preferably injected according to the sense of rotation of the shaft 6.

The grooves 22 which are provided opposite to the cooling channels 21-15 in the shaft 6 make sure that the heat-exchanging surface between the shaft 6 and the cooling oil is enlarged, and that the heat transfer from the shaft 6 to the cooling oil is thus promoted.

Next, the heated cooling oil is carried back to the reservoir 24 via a second cooling channel 21, 15.

Thanks to the small clearance between the shaft 6 and the sealing lips 20, only a very small amount of cooling oil will leak away to the inner space of the housing 2. The limited amount of cooling oil which leaks away to this space is discharged via the channel 28 in the bearing cap 4.

Since the lubricating oil only serves to lubricate and not to cool the bearings 7, the delivery of the lubricating oil can be restricted, such that the bearing losses are strongly reduced and the temperature in the

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Claims.

(54)

- 1.- Machine with an improved bearing lubrication, which machine mainly consists of a housing (2) and a rotor (5) which is provided on a shaft (6), provided in a rotatable manner in the above-mentioned housing (2) by means of oil-lubricated bearings (7), whereby, inside the housing (2), lubrication ducts (14) are provided to supply and discharge oil to and from the bearings (7), characterised in that it is provided with cooling channels (21,15) to supply and discharge a cooling agent, which cooling channels (21,15) open opposite to the shaft (6), in a place between the rotor (5) and an above-mentioned bearing (7) and in that the above-mentioned cooling channels (21,15) are connected to the above-mentioned lubrication ducts (14).
- 2.- Machine with an improved bearing lubrication according to claim 1, characterised in that the rotor (5) on the above-mentioned place opposite to the cooling channels (21,15) is provided with one or several grooves (22).
- 3.- Machine with an improved bearing lubrication according to claim 2, characterised in that the cooling channels (21,15) extend through a gasket (18), provided on both sides of the above-mentioned grooves (22) of sealing lips (20) directed towards the shaft (6).

4.- Machine with an improved bearing lubrication according to claim 3, characterised in that the clearance between the above-mentioned sealing lips (20) and the shaft (6) is very small.

5 5.- Machine with an improved bearing lubrication according to claim 3, characterised in that the above-mentioned cooling channels (21,15) open between the above-mentioned sealing lips (20).

10 6.- Machine with an improved bearing lubrication according to claim 5, characterised in that the above-mentioned cooling channels (21,15) are tangentially directed onto the shaft (6) at their outlet at the shaft (6).

15 7.- Machine with an improved bearing lubrication according to claim 6, characterised in that the cooling channels (21,15) are oriented such that they inject the cooling agent according to the sense of rotation of the shaft (6).

20 8.- Machine with an improved bearing lubrication according to claim 1, characterised in that the shaft (6) is provided with a thermal bridge (30) between the cooled part and the bearing.

25 9.- Machine with an improved bearing lubrication according to claim 8, characterised in that the shaft (6) is made of several parts, namely bearing-mounted parts (31) and non-bearing-mounted parts (32), whereby the

thermal bridge (30) is formed of a ring (33) made of a thermally insulating material, which is provided between the above-mentioned bearing-mounted and non-bearing-mounted parts (31 and 32) .

5 10.- Machine with an improved bearing lubrication according to claim 8, characterised in that the thermal bridge (30) is formed of a bush (34) made of a thermally insulating material, which is provided between the shaft (6) and the bearing (7).

10 ~~11.- Machine with an improved bearing lubrication according to claim 1, characterised in that the above-mentioned cooling channels (21-15) are connected to the above-mentioned lubrication ducts (14).~~

¹¹
15 ~~12.-~~ Machine with an improved bearing lubrication according to claim 1, characterised in that the lubrication ducts (14) and the cooling channels (21, 15) are provided in a bearing cap (4) which is part of the housing (2).

¹²
20 ~~13.-~~ Machine with an improved bearing lubrication according to claim ¹¹~~12~~, characterised in that the above-mentioned bearing cap (4) is provided with a cooling.

¹³
25 ~~14.-~~ Machine with an improved bearing lubrication according to claim ¹²~~13~~, characterised in that the lubrication ducts (14), the cooling channels (21, 15) of the shaft (6) and the cooling channels (35) of the bearing cap (4) are connected to each other.

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¹⁴
~~15~~.-- Machine with an improved bearing lubrication
according to claim ~~12~~¹¹, characterised in that, in case the
machine is an electric motor (1) or generator, the winding
heads (38) of the electric coils (37) are cased in a
s heat-conducting material (39) which makes contact with the
above-mentioned bearing cap (4).